Prolonged Stretching: its Effect on Crouch Gait of Diplegic Cerebral Palsied Children

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ABSTRACT

The purpose of this study was to evaluate the effect of prolonged stretching for both calf muscles simultaneously, using wooden stretcher, on improving diplegic gait of cerebral palsied children. This study included fifteen diplegic cerebral palsied children from both sexes with age ranged from 6 to 8 ($\overline{X}$6.2). They were selected from out patient clinic of Faculty of Physical Therapy, Cairo university, on a basic criteria. Hoffman reflex/myogenic response (H/M) ratio and gait pattern were assessed before and after treatment. The treatment program included prolonged stretching using wooden stretcher in addition to traditional physical therapy modalities. It was conducted for 4 months, 4 times/week. At the end of study the results revealed significant reduction in H/M ratio which in turn resulted in functional improvement of diplegic walking pattern. This improvement could be attributed to the cumulative effect of stretching protocol and traditional physical therapy modalities.

INTRODUCTION

Cerebral palsied (CP) children may have a variety of motor problems. Some are directly related to the lesion in the central nervous system, influencing muscle tone, balance and strength (primary problems) whereas static muscle contractures and bony deformities (secondary problems) develop slowly over time in response to the primary problems and to growth[12]. Contractures are the most common impairments associated with the spastic type of CP[13]. Many inter related factors have been proposed to cause contractures in CP children including more activation of muscles on one side of a joint than on the other side, changes in connective tissues, muscle length, slow muscle growth and positioning[15]. Spastic CP children who do not walk and whose voluntary movement is restricted to the extent that they cannot independently move their joints through the full range of motion during daily activities are at particularly high risk for developing a contracture[9].

Spastic diplegia is a common form about 32% of CP children including premature and term children[11]. The gait of these children is typically described as a crouch gait. It was defined as persistent dynamic knee flexion - [4]. Hip flexion and equines ankle deformities frequently accompanied with knee flexion in crouch gait[8].

Several physiotherapeutic modalities are available in the management of soft tissue tightness in the presence of spasticity, including stretching[7], positioning and serial casting[18]. Passive stretching is one of physical therapy interventions for reduction of contracture associated with CP[14]. Prolonged stretching is used in reducing knee and ankle contractures in CP children[17].

The purpose of the present study was to evaluate the effects of prolonged stretching for both calf muscles simultaneously (using wooden stretcher) on inhibiting spasticity and inturn improving gait pattern in diplegic CP children.

SUBJECTS, INSTRUMENTS AND PROCEDURES

Subjects

Fifteen diplegic cerebral palsied children (6 girls, 9 boys) between 6 and 8 years ($\overline{X}$ 6.2) participated in this study. All patients were selected from out patient clinic of Faculty of Physical Therapy according to the following criteria.

1- Spasiticity in lower limbs ranged from 3 to 4 grade according to Oswestry Scale[5].
2- Mild tightness in calf muscles, knee and hip flexors.
3- Absence of structural deformities in lower limbs.
4- Can walk without assistance (crouch gait).
5- No significance perceptual defects and their intelligence quotient ware within normal range.

Instruments

1- Computerized electromyographic apparatus (EMG).
2- Video camera, video tapes and video set.
3- Television with flat screen.
4- Reflected dots, sticky material, protractor, ruler and fine pen.
5- Wooden stretcher designed to stretch calf muscles for both lower limbs simultaneously while, the patient was (base) 40cm x 45cm, wooden board (back) 40 cm x 45cm and movable wooden board holds at 4 angles, fig (1).
6- Knee extension immobilizer.
7- Adjustable support rails.
8- Medical balls, rolls, wedges and mat.

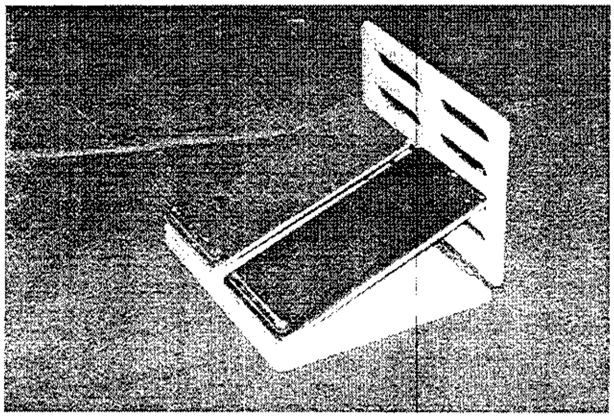

Fig. (1): Wooden Stretcher.

(A) Evaluation

I- H/M ratio

The child was placed in prone position, his head in mid position. Active electrode was placed along the mid dorsal line of lower leg, 2 cm below the point of separation of the gastrocnemius and secured by adhesive plaster. In different electrode was placed distal to active electrode at tendo-achilis and secured by adhesive plaster. The earth electrode was set between stimulating and recording electrodes. The stimulating electrode was place over the tibial nerve just medial to the mid point of the knee in the popliteal fossa. Maximum Hoffman reflex and maximum myogenic responses were recorded and H/M ratio was calculated.

II- Gait evaluation

The reflected dots were placed over the anatomical landmarks of the child's lower limbs (greater trochanter, lateral knee joint line, lateral malleolus, 5th metatarsal base).

Free gait was recorded as the patients traversed 10 meters walkway, the data being collected during the middle six meters. Each child was videotaped from the sagittal plane for both sides. The videotape was advanced frame by frame. Mean peak angles at the hip, knee and ankle were identified for both lower limbs during stance phase at initial contact, mid stance and terminal stance (heel off).

(B) Treatment

Treatment was carried out for 4 months, 4 times/week. Each session included.

1- Stretching protocol

I- Prolonged stretching for both calf muscles at the same time using wooden stretcher. Each child was instructed to wear knee extension immobilizer for both lower limbs. The patient stood on wooden stretcher and hold on horizontal rail in front of him for 10 minutes for every angles 15°, 30°, 45°, 60° respectively, 5 minutes rest in between. Every child was asked to maintain his back straight, (stretch intensity is equal child's body weight)[17].

II- Manual stretching for knee and hip flexors of both lower limbs.

Stretching procedure must be stopped if the child suffers from pain and fatigue.

2- Traditional methods of treatment included

- Activation and strengthening the weak agonist using approximation, tapping, traction, manual contacts and quick stretch[17].
- Facilitation of postural reactions (righting, equilibrium and protective reactions).
- Gait training.

RESULTS

When the pre and post treatment mean values were compared at the end of the study (4 months) the results revealed a significant reduction in H/M ratio for both lower limbs (P<0.05) as shown in table (1) and fig. (2).

Table (2) represent the mean ± SD values for right (Rt) hip, knee and ankle angles during stance phase pre and post treatment. Ankle planter flexion was significantly reduced by an average of 7.57° at initial contact, 8.93° during mid stance, 6.5° during terminal stance (P<0.01). While the knee flexion decreased by an average of 8.87°, 7.67° and 6.27° at initial contact, mid stance and terminal stance respectively (P<0.05). On the other hand, the hip flexion reduced by an average of 5.63°, 4.3° at initial contact and mid stance respectively, (P<0.05). The hip extension in terminal stance improved by 3° (P<0.05).

As indicated from table (3), a significant difference has been observed in the mean values for three joints of left (Lt) lower limbs during stance phase of gait at the end of treatment. Ankle planter flexion was significantly reduced by an average of 8° at initial contact, 8.87° during mid stance, 6.6° during terminal stance (P<0.01). While knee flexion decreased 7.53°, 7.74° and 5.66° at initial contact, mid stance and terminal stance respectively, (P<0.05). The average reduction for hip joint was 6.24° at initial contact 3.9° during mid stance (P<0.05). The hip extension improved by 4° in terminal stance (P<0.05).

Table (1): Shows H/M ratio before and after suggested period of treatment.

H/M ratio	Pre	Post	MD	t	P
	Mean ± SD	**Mean ± SD**			
Rt LL	45.85 ± 8.43	37.7± 8.2	8.15	2.59	0.05*
Lt L.L	44.99 ± 8.86	37.32 ± 8.29	7.67	2.37	0.05*

* Significant. Rt LL: right lower limb Lt LL: left lower limb

Table (2): Comparison of mean values of Rt hip, knee and ankle joint angles during stance phase pre and post treatment.

Item	Pre Mean ± SD	Post Mean ± SD	MD	t	P
- Hip joint					
Initial contact	35.13 ± 5.57	29.53±5.3	5.63	2.73	0.05*
Mid stance	14 ± 3.14	9.7± 2.7	4.3	3.8	0.05*
Terminal stance	10 ± 8	+3 ± 3	7	3.07	0.05*
- Knee joint					
Initial contact	32.13 ± 9.4	23.26 ± 8.9	8.87	2.55	0.05*
Mid stance	28.2 ± 7.29	20.53 ± 5.78	7.67	3.19	0.05*
Terminal stance	31.73 ± 5.98	25.46 ± 4.9	6.27	2.32	0.05*
- Ankle joint					
Initial contact	24.9 ± 3.76	17.33 ± 3.62	7.57	5.4	0.01**
Mid stance	24.46 ± 5.74	15.53 ± 4.9	8.93	4.44	0.01**
Terminal stance	22.4 ± 3.55	15.9 ± 4.43	6.5	4.33	0.01**

* Sig ** H.Sig + extension

Table (3): Comparison of mean values of left hip, knee and ankle joint angles during stance phase pre and post treatment.

Item	Pre Mean ± SD	Post Mean ± SD	MD	t	P
- Hip joint					
Initial contact	36.5 ± 4.9	30.26 ± 5.14	6.24	3.28	0.05*
Mid stance	15.8 ± 2.45	11.9 ± 2.73	3.9	3.8	0.05*
Terminal stance	12 ± 9	+4 ± 3	8	3.16	0.05*
- Knee joint					
Initial contact	32.33 ± 8.69	24.8 ± 8.22	7.53	2.36	<0.05*
Mid stance	27 ± 8.05	19.26 ± 5.13	7.74	2.76	<0.05*
Terminal stance	33.26 ± 5.66	27.6 ± 5	5.66	2.8	<0.05*
- Ankle joint					
Initial contact	26.4 ± 3.47	18.4 ± 3.28	8	5.7	<0.01**
Mid stance	26.33 ± 5.47	17.46 ± 5.12	8.87	4.45	<0.01**
Terminal stance	24 ± 4.35	17.4 ± 3.9	6.6	4.4	<0.01**

* Sig ** H.Sig + extension

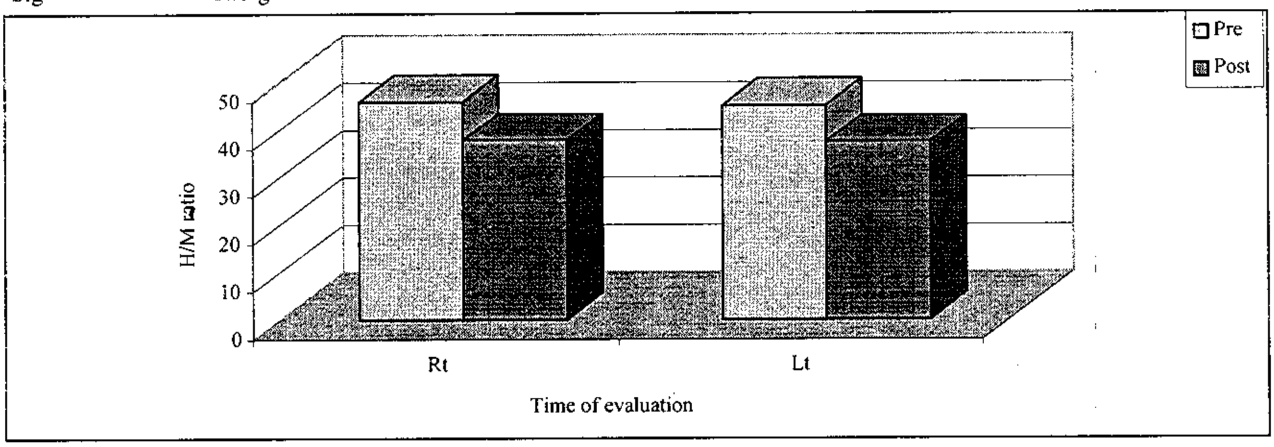

Fig. (2): H/M ratio before and after treatment.

DISCUSSION

The results collected from the present study demonstrated the effect of prolonged stretch in addition to the traditional physical therapy program in improving gait pattern of diplegic children.

One of the greatest problems that physical therapist often face during habilitation of CP children is the muscle tone abnormalities which hamper the abilities of those children in achieving normal gait pattern.

In diplegice, the abnormal gait pattern is resulting from:

- Hip flexion and internal rotation, due to over activity by illiospoas, rectus femoris and hip adductors.
- Knee flexion due to overactivity of hamstrings.
- Equinus deformity of the foot due to over activity by triceps surae[18].

The pre treatment results of the present study reveled an increase in all measured joint's angles for both lower limbs which indicated that those children had abnormal gait pattern.

Regarding to the results of this study, at the end of treatment, there was significant reduction in mean values of H/M ratio recorded from soleus muscles for both lower limbs, as compared with mean values before treatment ($P<0.05$) table (1), fig. (2). These results come in agreement with the results of Joodaki et al., (2001)[(10)] who stated that reduction of amplitude of H/M ratio demonstrates significant inhibition of spasticity in those patients. So, it indicated that most patients in this study get benefit from the specific stretching protocol in addition to traditional methods of treatment.

The rationale of the prolonged stretching for both calf muscles simultaneously using wooden stretcher may be attributed to:

- Active participation by the child being stretched (auto passive stretch).
- The advantages of positioning at the point of maximum tolerated length of contracted muscle16.
- Weight bearing position17.
- Activate golgi tendon and joint receptors resulting in autogenic inhibition of the muscles being stretched16.
- Activate the weak agonist via using tactile stimulation. Activation and strengthening of the weak agonist give better muscle balance around the joint, reducing the potential for recurrence myostatic contracture[16].

Watkins (1999)[18] reviewed some of the main theories on the mechanical changes in muscle structure and function in the presence of spasticity.

(1) Abnormal Cross bridges attachments

After myosin cross bridges engage with actin during an active contraction, they fail to disengage readily or reengage readily but with a much lower detachment rate. This theory may be applied to the equines deformity occurring in the presence of spasticity. It could be hypothesized that after contraction of plantar flexors a failure of myosin cross bridges to disengage would result in shortened muscle tissue with an increase in the overlapping of the cross bridges[2]. A decrease in cross bridge overlap may occur when a slow passive stretch is applied to lengthen the muscle tissue[18].

(2) Reduction in sarcomere numbers

Immobilisation in a shortened position results in a decrease in the numbers of sarcomere[6]. Several studies indicate that immbolisation using casting in lengthened position over a period of time increases sarcomere number and results in an increase in muscle length[18].

(3) Connective tissue plasticity

Connective tissue develop tensile force which causes slow progressive shortening of that connective tissue until stopped by an opposing force[15]. It can be theorized that moderate prolonged tension to equines deformity over a period of time would allow this connective tissue to elongate plasticity[18].

Regarding to the results of gait evaluation, each of three joints for both lower limbs showed significant improvement during stance phase after treatment, tables (2,3). Thus the mobility at both ankles improved, however the majority of patients still had some degree of residual knee flexion throughout stance and did not attain normal knee motion. These findings supported by Cahen et al., (1990)[1] who stated that persistent knee flexion can be related to weak plantar flexors, which are unable to control forward tibial advancement caused by momentum and anterior displacement of body mass.

Most of diplegic children obtained smoother gait, with more symmetrical posture and their balance improved after treatment. These improvements in gait come in agreement with Holt et al., (2000)[9]; Olney and wright (2000)[14] who documented the importance of using passive stretching exercises for prevention or reduction of contractures associated with cerebral palsy.

CONCLUSION

From previous discussion of the results of this study and according to reports of the investigators in the fields related to the present study, it can be suggested that prolonged stretching, in addition to traditional physical program can improve gait pattern of diplegic cerebral palsied children.

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الملخص العربي

تأثير الشد المستمر على المشية الجاثمة للأطفال ذوي الشلل المخي

الهدف من هذه الدراسة هو تقويم تأثير الشد المستمر لعضلتى السمانة على أنموذج السير عن الأطفال المصابين بالشلل المخى من النوع التقلصي الذي يصيب الطرفين السفليين بأشد من الطرفين العلويين وقد استخدم جهاز خشبي.
وقــد تــم تقويم درجة تقلص العضلات (النغمة العضلية) عن طريق الحساب النسبى هـ/م وقد تم تقويم أداء المشى عند الأطفال بواسطة التصوير بكاميرا فيديو وتحليل زوايا الحركة ومعدلات تغيرها.
اشــترك في هذه الدراسة خمسة عشر طفلا من الجنسين وكان متوسط أعمارهم ٦,٢ سنوات ويعانوا من الشلل المخى وقد تم تقويمهم قبل بدء البرنامج العلاجى ثم بعد أربعة أشهر من العلاج بمعدل ٤ جلسات اسبوعيا واحتوى هذا البرنامج على أساليب العلاج التقليدى بالاضافة إلى الشد العضلى وذلك باستخدام الجهاز الخشبى وقد اسفرت النتائج إلى تحسن ذو دلالة احصائية فى معدل هـ/م مما له تأثير ايجابى فى تحسن نمط المشى لدى هؤلاء الأطفال .